ARMY RESEARCH LABORATORY

# The Information Distribution Technology: *LIBXMAP* - Application Program Interface

Kenneth G. Smith
Holly A. Ingham

ARL-TR-498 August 1994

## NOTICES

Destroy this report when it is no longer needed. DO NOT return it to the originator.

Additional copies of this report may be obtained from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The use of trade names or manufacturers' names in this report does not constitute indorsement of any commercial product.

# REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188



| 1. AGENCY USE ONLY (Leave blank) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | August 1994 | Final, Jan 92 - Jun 93 |

**4. TITLE AND SUBTITLE**
The Information Distribution Technology: *LIBXMAP* - Application Program Interface

**5. FUNDING NUMBERS**
4B592-462-52-3026
CC: 4B5200

**6. AUTHOR(S)**
Kenneth G. Smith and Holly A. Ingham

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
U.S. Army Research Laboratory
ATTN: AMSRL-CI-SB
Aberdeen Proving Ground, MD 21005-5067

**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
U.S. Army Research Laboratory
ATTN: AMSRL-OP-AP-L
Aberdeen Proving Ground, MD 21005-5066

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**
ARL-TR-498

**11. SUPPLEMENTARY NOTES**

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**
Approved for public release; distribution is unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** (*Maximum 200 words*)

The Military Computer Science Branch (MCSB) of the Advanced Computational and Information Sciences Directorate (ACISD) of the Army Research Laboratory (ARL) has been developing concepts to provide enhanced information exchange capabilities to "fighting level" commanders and soldiers as part of an ongoing, long-term research effort known as the Information Distribution Technology (IDT). The IDT concepts have been successfully demonstrated on numerous occasions, most notably during the 1989 LABCOM Smart Weapons Cooperative Program Demonstration and the 1991 Second Counter-Air Symposium for Army Aviation and Air Defense. The report discusses a new software library created to facilitate the development of integrated application programs for testing, refining, and demonstrating existing and emerging IDT concepts.

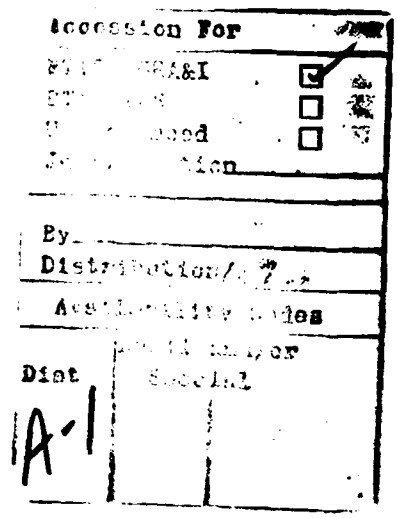
| 14. SUBJECT TERMS | 15. NUMBER OF PAGES |
|---|---|
| application program interface, IDS, IDT, information systems, tactical data systems | 32 |
| | 16. PRICE CODE |

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| UNCLASSIFIED | UNCLASSIFIED | UNCLASSIFIED | UL |

INTENTIONALLY LEFT BLANK.

# PREFACE

The Military Computer Science Branch (MCSB) of the Advanced Computational and Informational Sciences Directorate (ACISD) of the Army Research Laboratory (ARL) has been developing concepts to provide enhanced information exchange capabilities to "fighting level" commanders and soldiers as part of an on–going, long term research effort known as the Information Distribution Technology (IDT). The IDT concepts have been successfully demonstrated on numerous occasions, most notably during the 1989 LABCOM Smart Weapons Systems Cooperative Program Demonstration and the 1991 Second Counter–Air Symposium for Army Aviation and Air Defense. This report discusses a new software library created to facilitate the development of integrated application programs for testing, refining, and demonstrating existing and emerging IDT concepts. The authors wish to thank Eric Heilman and Fred Brundick for their insightful contributions in reviewing this report.



INTENTIONALLY LEFT BLANK.

# TABLE OF CONTENTS

INTENTIONALLY LEFT BLANK.

# LIST OF FIGURES

INTENTIONALLY LEFT BLANK.

# 1. INTRODUCTION

The Military Computer Science Branch (MCSB) of the Advanced Computational and Informational Sciences Directorate (ACISD) of the Army Research Laboratory (ARL) has been developing concepts to provide enhanced information exchange capabilities to "fighting level" commanders and soldiers as part of an on-going, long-term research effort known as the Information Distribution Technology (IDT). The goal of the IDT project is to facilitate the exchange of tactical information over standard combat net radios (CNR) at data rates as low as 1,200 bits per second. To satisfy this goal, the IDT seeks to improve information distribution by exchanging data as concisely as possible, only when absolutely necessary, and as efficiently as possible.

Paramount to the success of the IDT is the ability to test, evaluate, and demonstrate information distribution concepts being developed. For this purpose, several prototype experimental software application programs were developed. As the IDT matured, new application programs were needed that could more readily address the information distribution concepts. Hence, a new suite of demonstration application programs was developed. These new programs are designed to be more portable, more flexible, easily tailored, quick to develop, and integrateable with each other. A key component of the new application programs was an interface library called *libxmap* which is the focus of this report.

# 2. OVERVIEW

## 2.1 Information Distribution Technology

The IDT is prototype software designed to provide enhanced information exchange capabilities to "fighting level" commanders and soldiers. The goal of the IDT project is to facilitate the exchange of tactical information over CNRs at data rates as low as 1200 bits per second. The development of the IDT is guided by three tenets for exchanging battlefield information (Chamberlain, 1990). Data is exchanged 1) as concisely as possible, 2) only when absolutely necessary, and 3) as efficiently as possible. Further, the IDT seeks to combine military science technology with state-of-the-art computer science technology to produce a powerful, effective, and flexible information exchange technology.

At the heart of the IDT is a free-form distributed factbase (DFB) that stores all of the information pertinent to a battlefield situation (Hartwig, 1991). A security control module (SCM) controls the flow of information into and out of the DFB. Data distribution rules provide the SCM with guidance for exchanging information with other DFBs. This information exchange is handled by the IDT's fact exchange protocol (FEP) (Kaste, 1990). "Triggers" within the DFB allow application programs to be notified when specific information is entered into the DFB that may be of interest to application programs. Lastly, an interface (I/F) exists that allows sophisticated application programs to extract, enter, and modify information stored in the DFB. See Figure 1.

Information stored in a DFB is an abstract representation of military concepts and current battlefield perceptions. Information is stored and manipulated in a manner consistent with the design tenets of the IDT. It is stored in the DFB in "facts" – logical groupings of data representing a unique item, event, or activity. Each fact is an instantiation of a pre-defined data structure called a facttype. A facttype is a template that defines the structure of a fact; i.e., the names of the fields in a fact and the type of data each field represents.

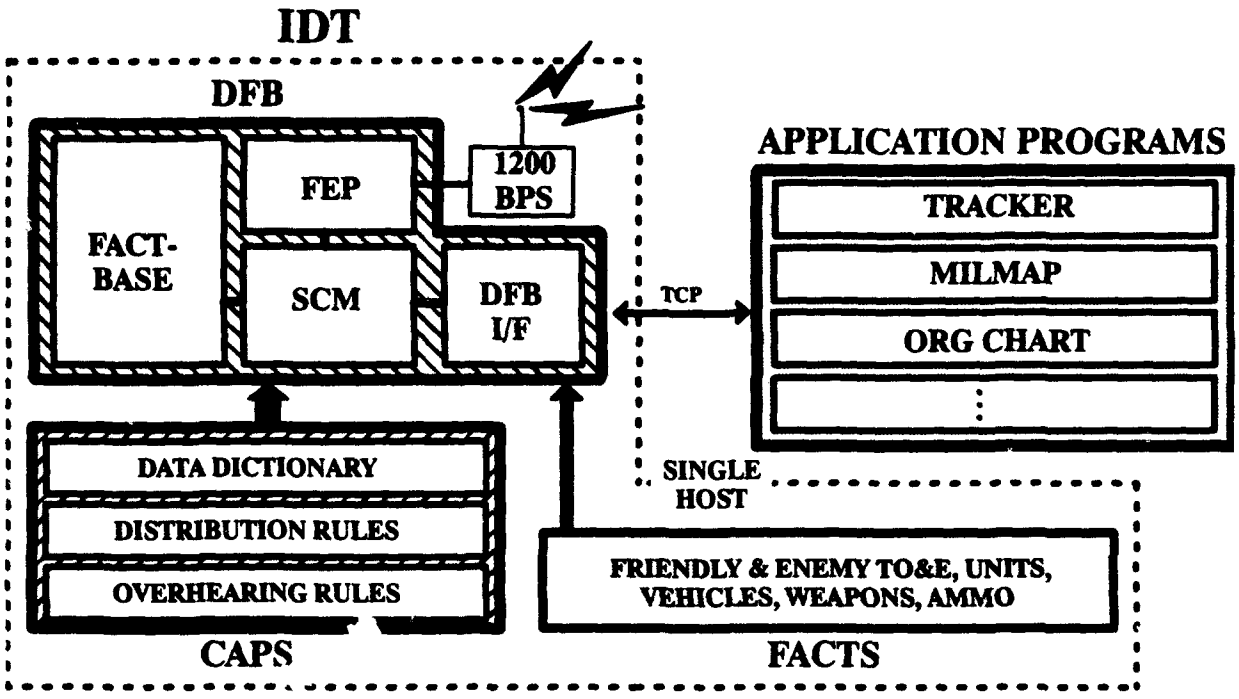



Figure 1. Information Distribution Technology

Data is stored in the DFB so as to be most manipulable by computers, not by humans. One of the functions of application programs is to enter and subsequently modify data in the DFB. Application programs provide the unique service† of presenting DFB data in a form that is easily understood and manipulable by humans. Application program interfaces are the means for testing, evaluating, and demonstrating the IDT concepts.

### 2.2 Application Programs

To date, several application programs have been developed that, working in concert with each other, demonstrate these concepts. A viable, militarily sound and realistic IDT demonstration package has been developed to exercise the IDT concepts.

Leveraging off of earlier involvement in the 1989 Smart Weapons Systems (SWS) LABCOM Cooperative Program demonstration and the 1991 joint Human Engineering Laboratory–Ballistic Research Laboratory Counter–Air Program (HELCAP) demonstration, six application programs have been developed. These application programs are *Xmap, Milmap, Org Chart, Vtracker, Tracker,* and *Extract*. They provide the capability to demonstrate IDT concepts being used to exchange battlefield information based on both a ground and air war scenario consistent with a high–intensity European–based conflict in the area of the Fulda Gap region of Germany.

*Extract* and *Tracker* are the scenario driver programs providing the data depicting the ground and air war, respectively. *Milmap, Vtracker,* and *Org Chart* are user application programs that allow a commander to view/monitor the battle as it unfolds. *Xmap* is a general pur-

† The uniqueness of this service stems from the fact that data can be entered or modified in the DFB via the FEP. However, only application programs are capable of presenting data in a user–friendly format.

pose mapping application program that provides the common medium upon which unit and other overlay symbols are placed while viewing the battle. *Milmap, Vtracker,* and *Org Chart* use *Xmap* for all map–related functions (drawing unit symbols, range fans, routes, borders, areas, etc.) and can interact with each other through it. The means by which application programs communicate with *Xmap* is via the *libxmap* software library.

# 3. LIBXMAP

## 3.1 General Overview

*Libxmap* is a library of software routines used by *Xmap* and client application programs that communicate with it. Such application programs will be hereafter referred to interchangeably as "clients," "client programs," or "client application programs." *Xmap* and application programs that connect to *Xmap* follow a client–server paradigm, where *Xmap* is the server. Within this paradigm, the *Xmap* server provides the basic or generic capabilities for displaying a map and overlay symbols. For developmental purposes, the map used was digitized from a photograph of a 1:100,000 scale map of the Hunfeld region of Germany. *Xmap* is written in C and uses the X Window System. It provides map manipulation capabilities for zooming, panning, resizing the display window, turning on or off grid lines, and for creating and/or editing lines.

Client programs provide the link between *Xmap* and the military information to be displayed in *Xmap*. Clients decide when, where, and what information to display on the map in the form of map "overlays." This information is sent to *Xmap* via the standardized library, *libxmap*.

The client–server paradigm for application programs improves the IDT demonstration by 1) speeding up the development of client, or "military," application programs, 2) providing a single common map display program useable by all application programs, and 3) eliminating the need for client programs to concern themselves with windowing issues (e.g., resizing, exposures, drawing overlays that aren't in the field of view, etc.). This architecture allows client application programs to be developed quickly and reliably and does not require the developer to be an expert in developing graphical user interfaces. See Figure 2.

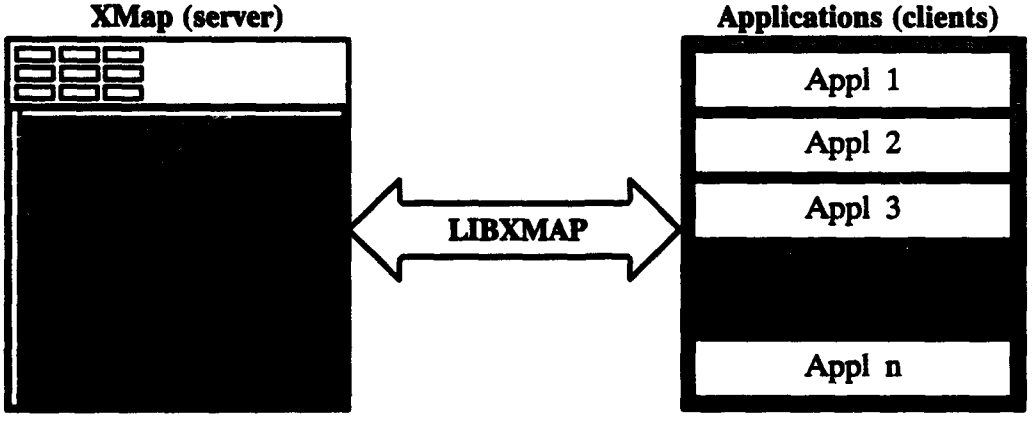



Figure 2. Libxmap Architecture

### 3.2 Functional Review

*Libxmap* is a collection of subroutines that are used to exchange information between *Xmap* and client programs. Client programs connect to *Xmap* and then command it to draw objects, modify existing objects, and remove objects. *Xmap* complies with these commands while providing a user window interface (e.g., mouse interaction, window resize capability, etc). Events that may be of interest to clients, such as mouse clicks on objects drawn by *Xmap*, are relayed to the client programs by *Xmap* through *libxmap*. In this fashion client programs maintain control over the objects that they commanded *Xmap* to display. There are two key concepts underlying the interaction between client programs and *Xmap*: objects and events.

#### 3.2.1 Objects

Objects are the main component, or unit of information, on which *Xmap* and client programs interact. Client programs command Xmap to create, modify, or remove objects. To client programs, these objects take the form of unit symbols, map symbology, points, lines, routes, areas, etc. To *Xmap*, these are all just objects. To provide a means for client programs and *Xmap* to act on sets and/or subsets of objects, attributes are associated with each object that categorize them into object types and classes. These attributes are optionally set by client programs. As of the writing of this report, only a small number of types and classes have been defined and are explained in Appendix A.

#### 3.2.2 Events

Events are actions that are performed by the user through *Xmap's* user interface. Client programs can register their interest in specific events with *Xmap* or default to receive notification of all events. Typically, events occur on objects via mouse button presses. Other events are line modification and object relocation. Button press events generate a BUTTON_PRESS event communication from *Xmap* to clients identifying which mouse button was pressed and on which object the mouse was pressed. The modification of lines (performed through *Xmap's* user interface) generates a LINE_CHANGE event that identifies the line that was modified and the new coordinates of the segments comprising the line.

Certain commands from client programs may have an indirect impact on other objects. For instance, moving one object may cause another object to move automatically. For such a case, Xmap generates a SYMBOL_CHANGE event identifying the object that changed and its new location. Such indirect changes occur with "associated" objects.

#### 3.2.3 Links and Associations

Objects may be linked together to form logical relationships to simplify client programming. *Libxmap* imposes no constraints on *why* objects are linked; it simply provides the capability *to* link them. There are no restrictions on the number or type (one–to–one, one–to–many, or many–to–one) of links between objects. *Libxmap* distinguishes between two kinds of links, referred to simply as "links" and "associations."

"Links" are a one–to–one relationship used to visually bind two objects. *Xmap* draws a line between objects that are "linked." If one of the objects move, then the line between them follows it automatically. If either object is removed, then the line (and link) between them is automatically removed.

Associations form a relationship between objects that governs the way objects respond to actions. Associations enable related objects to perform as a group. Unlike linked objects

associated objects have no line drawn between them in *Xmap* (although, associated objects can also be linked if a connecting line is desired). Associations are used to spatially bind objects. That is, when one object moves, any associated objects will also move to maintain their relative physical position to the moved object. There are two types of associations: MASTER_SLAVE and GROUP. In MASTER_SLAVE associations, if the master object moves, then any slave objects will follow it, but not vice versa. In a GROUP association, if either object moves, then all other objects follow it.

## 4. LIBXMAP Functions

*Libxmap* is divided into two sets of routines that provide for client–to–*Xmap* communication and *Xmap*–to–client communication. Client–to–*Xmap* commands, or client commands, are routines by which client programs connect and send object draw/modify requests to *Xmap*. *Xmap*–to–client commands, or *Xmap* commands, enable *Xmap* to send synchronous and asynchronous information to client programs.

Below is a brief description of each command. For readability, the commands are italicized and followed by open and closed parentheses, e.g., *command_name()*. *Xmap*–to–client commands are differentiated from client–to–*Xmap* commands by a preceding underscore character, "_", in the command name. More detailed information on each command can be found in Appendix B.

### 4.1 Client–to–Xmap Commands

*Xmap_connect()* is the command used by client programs to connect to *Xmap*. This command allows clients to request notification of event occurrences. Upon successful connection *Xmap* assigns a unique identification number to the client and returns that number to the client for use in all future exchanges. Clients terminate their connection to *Xmap* via the *xmap_close()* command.

Clients instruct *Xmap* to draw an object using the *xmap_draw_symbol()* command. The object's location, foreground and background colors, class type and size are specified. For referencing purposes, *Xmap* returns an object identification number to the client. The object identification number and the client identification number uniquely identify an object. Attributes of objects can be modified via the *xmap_change_symbol()* command. Objects may be removed singularly using the *xmap_remove_symbol()* command. The *xmap_remove_class()* command removes all objects of the specified class type for the particular client.

There are two ways for clients to draw lines: *xmap_add_line()* and *xmap_convert_line()*. The *xmap_add_line()* command is used when the client supplies the end points of the segments defining the line to be drawn. The *xmap_convert_line()* command is used when a client converts a line created locally via *Xmap* to a line "owned" by the client. Lines are modified via the *xmap_change_line()* command. The *xmap_remove_line()* command is used to remove lines.

To show that two objects are linked together (illustrated by a line connecting the two objects in *Xmap*), the *xmap_add_link()* command is used. Links are removed via the *xmap_remove_link()* command. Objects can be associated (with no visible link) using the *xmap_add_association()* command. Associations are removed using the *xmap_remove_association()* command.

A somewhat specialized command exists to instruct *Xmap* to draw range fans. Range fans are used to show the area in which a weapon system is able to fire. To draw a range fan the

*xmap_draw_rangefan()* command is used. Subsequently, range fans are removed using *xmap_remove_rangefans()*. Range fans originate from the center point of an object that is identified in the *xmap_draw_rangefan()* command. Range fans are automatically associated with the object from which they originate.

### 4.2 Xmap–to–Client Commands

*_Xmap_connect()* is the command used by *Xmap* to establish itself as the server in the client–server paradigm. Once initialized, it listens for new client connections and polls any existing connections for new client requests. When a new client connects, *Xmap* sends a unique number to the connecting client via the *_xmap_send()* command to be used by the client in all future communications with *Xmap*. Connected clients are informed of an impending closure of the network server connection via the *_xmap_close()* command. Errors are reported to clients via the *_xmap_error()* command.

Clients are notified of any generic button press events via the *_xmap_button_press()* command. A generic button press event, or "click," is classified as a mouse button press occurring anywhere within the *Xmap* display window. *Xmap* sends clients the unique object identification number of the clicked object (or 0 to indicate the map background, not an object, was pressed), the mouse button number that caused the event, and the map grid location (easting and northing) of the button press.

When a user clicks on a line, *Xmap* responds by sending a line click message via the *_xmap_line_click()* command. This command contains the corresponding easting and northing coordinates of each segment comprising the clicked line. *_Xmap_line_change()* is a command used by *Xmap* to inform a client when a line has been edited by the user through *Xmap's* line editing control panel.

Association of objects using a MASTER/SLAVE configuration can cause a change in location of one object when the other object's location is changed. Clients are informed of the location of the "slaved" object via the *_xmap_symbol_change()* command.

## 5. Conclusion

The libxmap library is an integral component of the application programs used to test, evaluate, and demonstrate the information distribution concepts being developed and explored as part of the IDT. It provides a uniform medium for linking together the various demonstration application programs and provides the utility to facilitate the development and integration of new application programs.

## 6. REFERENCES


Chamberlain, Samuel C. "The Information Distribution System: IDS–An Overview." BRL–TR–3114, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, July 1990.

Hartwig, George Wm. Jr. "The Information Distribution System: The FactBase." BRL–TR–3247, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, July 1991.

Ingham, Holly A. "Xmap: A General Purpose Mapping Program." U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, to be published.

Kaste, Virginia A. "The Information Distribution System: The Fact Exchange Protocol–A Tactical Communications Protocol." BRL–MR–3856, U.S. Army Ballistic Rese Laboratory, Aberdeen Proving Ground, MD, August 1990.

Smith, Kenneth G. and Eric G. Heilman. "Information Distribution Technology Applied to Army Aviation and Air Defense Counter–Air Operations." BRL–TR–3397, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, September 1992.

Smith, Kenneth G. "Vtracker – An Air Track Report Scenario Driver." U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, to be published.

INTENTIONALLY LEFT BLANK.

# APPENDIX A:

# OBJECT TYPES AND CLASSES

INTENTIONALLY LEFT BLANK

## Objects and Classes

Application programs instruct *Xmap* to create, move, modify, and remove objects. To facilitate the application program's tasks of manipulating objects, they can be categorized into groups of classes. Application programs assign group and class attributes to each object they create. Groups and classes allow objects to be manipulated as a set so that operations can be performed en masse. For example, an application program can instruct *Xmap* to remove all objects of class "line."

The definitions and uses assigned to each group and class are not rigidly stated. During prototype development, they were created on an "as needed" basis as determined by the current application programs. To date, the potential in creating and assigning group and class attributes to objects has not been fully exploited.

### Object Groups

Below is a list of the current object groups along with a suggested use for each. Note that each group name starts with "OB" for OBject group.

- OB_SYMBOL – object is typically a unit symbol, although symbols exist for other features such as bridges, buildings, etc.
- OB_TEXT – object is a text string
- OB_POINT – object is a military operations "point," e.g., coordination point
- OB_LINE – object is a military operations "line," e.g., phase line, FEBA, border
- OB_AREA – object delineates an area, e.g., no fire zone
- OB_RANGEFAN – object depicts a unit's range fan (area in which its weapons can fire)
- OB_LINK – object "links" two other objects together with a visible line
- OB_ASSOCIATION – object "links" two other objects together spatially, i.e., if one object moves, the associated object will move with it, but with no visible line

### Object Classes

Below is a list of the current object classes along with a suggested use for each. Xmap requires that all objects be assigned a group and class identifier. Note that each class starts with "CL" for object CLass.

- CL_UNDEFINED – used by application program to specify no class attribute
- CL_UNIT – object is of group OB_SYMBOL and represents an actual unit
- CL_SENSING – object is of group OB_SYMBOL and represents the reported observation of a unit (typically an enemy unit)
- CL_LINE – object is of group OB_LINE. Possible future use is to have several different types (or classes) of lines
- CL_TRACK – object is of group OB_SYMBOL and represents an air defense track

- CL_LINK – object is of group OB_LINK (see OB_LINK above)
- CL_RANGEFAN – object is of group OB_RANGEFAN (see OB_RANGEFAN above)
- CL_POINT – object is of group OB_POINT (see OB_POINT above)

# APPENDIX B:

# LIBXMAP FUNCTIONS

INTENTIONALLY LEFT BLANK.

# Libxmap Functions

*Libxmap* is a software library of subroutines, or commands, used to exchange information between *Xmap* and client application programs. This appendix contains a listing of all of the commands along with a brief explanation of the arguments comprising each command and a short description. It is divided into two sections describing the commands available to client programs for communicating with *Xmap* and the commands available to *Xmap* for communicating with its clients.

## Client Commands

Below is a list of the commands available to client programs for communicating to *Xmap*. For each command there is a brief explanation of its intended use as well as its syntax.

```
/*
~ xmap_connect ( )
*
* Command used by application programs to open a connection to Xmap.
*/

struct pkg_conn *
xmap_connect( host, switch_array, ev_button, ev_keyboard, ev_geometry, ev_object);

char    *host;                          /* hostname to connect to */
struct  pkg_switch switch_array [ ];    /* array of switching routines */
int     ev_button                       /* application's interest of button events */
        ev_keyboard,                    /* application's interest of keyboard events */
        ev_geometry,                    /* application's interest of geometry events */
        ev_object;                      /* application's interest of object events */
```

"Host" is the name of the machine on which *Xmap* is running. "Switch_array" is used for specifying the routines in the client program that are called when *Xmap* sends information through the pkg protocol. "Ev_button," "ev_keyboard," "ev_geometry," and "ev_object" are flags used by the client to indicate its interest in X events of the named type that occur within *Xmap's* window. For example, if an object is picked using the mouse and a client set "ev_object" to TRUE then *Xmap* would notify the client which object was picked and by which mouse button. In response, *Xmap* sends a message back to the client giving it its unique client identification number by which *Xmap* identifies it.

Return: A pointer to a pkg connection structure. Each client program gets a unique pkg connection structure that is used by the pkg routines for communicating to the client programs.

```
/*
~ xmap_close( )
*
* Command used by application programs to close a connection to Xmap.
*/

xmap_close( conn )

struct pkg_conn *conn; /*Application program's connection to Xmap */
```

"Conn" is the pkg connection structure for this client (obtained when it first connected to *Xmap*). This routine informs *Xmap* that the client is closing its connection. Any objects that the client previously instructed *Xmap* to display are removed.

Return: Not used.

```
/*
~ xmap_send ( )
*
*Test routine for application program to send information to Xmap.
*/

xmap_send (msg_type, msg, conn)

int     msg_type;                   /* Define (from libxmap.h) */
char    *msg;                       /* Contents of message */
struct  pkg_conn *conn;             /* Application program's connection to Xmap */
```

"msg_type" is a #define that specifies the type of message that is being sent to *Xmap*. "msg" is the actual message. "conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~xmap_add_symbol ( )
*
* Routine used by application programs to draw symbols on the map.
* This routine draws NEW symbols, or "objects" to Xmap, hence a handle id
* must be associated with the symbol (object).
*/

int
xmap_add_symbol (symbol, fg_color, bg_color, scale, x, y, class, conn, fid, client_id)

char                *symbol;        /*Symbol string to draw. */
int                 fg_color,       /* Foreground color of symbol */
                    bg_color,       /* Background color of symbol */
                    x, y,           /* Map grid coordinates (easting, northing) */
                    class;          /* Class type of symbol object */
float               scale;          /* Scaling factor for symbol */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
dkb_factid_t        fid;            /* Fact id associated with this symbol. */
int                 client_id;      /* Client identifier number. */
```

This routine is used for drawing unit symbols on the map. To *Xmap*, a unit symbol is just another overlay symbol, or object. *Xmap* identifies objects by their handle id and the client id of the client program that submitted the command to draw the object. The handle id must be unique to a specific client. That is, objects drawn by a client must never share the same handle id. To ensure this uniqueness, and to alleviate the client programs from the burden and task of assigning unique handle ids, *libxmap* assigns the handle id for all new objects. "symbol" is a string recognized by the symbol drawing library, *symlib*, that describes the unit symbol to be drawn. "fg color" and "bg color" are #defines that are described in sym-

bol.h used for specifying the foreground and background colors of the symbol. "x" and "y" are the UTM map coordinates for where the symbol should be drawn. The center of the symbol is drawn at this coordinate. "class" is a #define that further identifies the type of object being drawn. The class defines are in libxmap.h. Though not yet implemented, the idea was that *Xmap* could be instructed to act on whole classes of objects rather than single objects. "scale" is the factor by which symbols are scaled down when drawn by the symbol drawing library. Typical values are defined in symbol.h. "conn" is the client's pkg connection structure. "fid" is the IDT fact id of the fact that is associated with the symbol being drawn. It is included so that other client programs that pick this symbol have a source of information pertaining to the symbol. "client_id" is the client identification number of the client that is drawing the symbol.

Return: Handle id of new object.

```
/*
~ xmap_change_symbol ( )
*
* Routine used by application programs to change attributes of a symbol
* drawn on the map. "handle" should have been previously assigned via
* xmap_add_symbol ( ). "trace" instructs Xmap whether or not to draw a
* (volatile) line from the old location to the new location showing the
* path of the symbol (if its location changed).
*/

void
xmap_change_symbol (handle, client_id, symbol, fg_color, bg_color, scale, x, y, class, trace, conn,
                    fid)

char                *symbol;        /* Symbol string to draw. */
int                 handle;         /* Handle id of object to change */
int                 client_id;      /* Client identifier number. */
int                 fg_color,       /* Foreground color of symbol */
                    bg color,       /* Background color of symbol */
                    class,          /* Object type class */
                    x, y;           /* Map grid coordinates (easing, northing) */
float               scale;          /* Scaling factor for symbol */
int                 trace;          /* Shows trail of moved symbol. */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
dkb_factid_t        fid;            /* Fact id associated with this symbol. */
```

This routine is used to change one or more attributes of objects that have been previously displayed (through xmap_add_symbol ( ) ). "symbol," "fg_color," "bg_color," "class," "x," "y," "scale," "trace," and "fid" can be changed. More than one attribute may be changed in a single call to xmap_change_symbol ( ). For details on each attribute, see xmap_add_symbol ( ).

Return: Not used.

```
/*
~ xmap_remove_symbol ( )
*
* Removes a previously added symbol.
*/

void
xmap remove symbol (handle, client_id, conn)

int                 handle;         /* Handle id of object to change */
int                 client_id;      /* Client identification number. */
struct pkg_conn     *conn           /* Application program's connection to Xmap. */
```

This routine is used to remove previously drawn symbols from *Xmap*. "handle_id" and "client_id" are the same as was used with xmap_add_symbol ( ). "conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~ xmap_remove_objects ( )
*
* Routine to remove all objects of a particular type, or all classes of a
* particular type of object.
*/

void
xmap_remove_objects (type, class, conn)

int                 type,           /* Type of object to remove */
                    class;          /* Class of object type to remove */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
```

This routine is used to remove a group of objects identified by their "class" or more specifically by a particular "type" of a "class." "type" and "class" definitions can be found in libx-map.h. "conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~ xmap_add_line ( )
*
* Routine used by application programs to draw lines on the map.
* This routine draws NEW lines, or "objects" to Xmap, hence a handle id
* must be associated with the line (object).
*/

int
xmap_add_line (client_id, fid, coords, conn)

int                 client_id;      /* Client identifier number. */
dkb_factid_t        fid;            /* Fact id associated with this line. */
char                *coords;        /* List of coords defining line segments. */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
```

This routine is used for drawing a line object in *Xmap*. Lines are defined to be a set of line segments identified by the coordinates of the endpoints of each segment. "client_id" is the client identification number of the client that is drawing the line. "fid" is the IDT factid of the fact that is associated with the line being drawn. "coords" is a list of UTM coordinates that specify the endpoints of the line segments that comprise the line. "conn" is the client's pkg connection structure.

Return: Handle id of new object (line).

```
/*
~ xmap_change_line ( )
*
* Routine used by application programs to change already drawn lines on the
* map. The complete list of new coordinates is specified.
*/

void
xmap_change_line (client_id,, handle, fid, coords, conn)
int                 client_id;          /* Client identifier number. */
int                 handle;             /* Handle id of line */
dkb_factid_t        fid;                /* Fact id associated with this line. */
char                *coords;            /* List of coords defining line segments. */
struct pkg_conn     *conn;              /* Application program's connection to Xmap */
```

This routine is used to modify an existing line in *Xmap*. The line to be modified is identified by "client_id" and "handle" (the handle of the line was assigned when the line was created by xmap_add_line ( ) or xmap_convert_to_line ( ) ). "fid" is the IDT factid of the fact that is associated with the line. Lines can only change by taking on a new shape; that is, line segments are added, deleted, or modified in the original line. The entire list of segments comprising the line must be stated in "coords," not just the new or different segments. "conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~xmap_convert_to_line ( )
*
* This routine is called when application programs want to instruct Xmap
* to convert a local line to a global line. Global lines are lines that
* application programs know about and have assigned fact ids to.
*/

int
xmap_convert_to_line (old_handle, old_client_id, new_client_id, fid, conn)
int                 old_handle,         /* Handle Xmap knows it by */
                    old_client_id,      /* Client id Xmap knows it by */
                    new_client_id;      /* New client id of line */
dkb_factid_t        fid;                /* Fact id of line fact associated with line */
struct pkg_conn     *conn               /* Application program's connection Xmap */
```

Free-hand creation of lines (that is, drawing lines using the mouse) is a function of *Xmap*. *Xmap* provides the user interface to allow for the creation of lines using the mouse to input

the endpoints of the line segments comprising the line. When a line is created this way, it is considered to be a local line in *Xmap*; that is, it is an object that has a handle id and client id that identify it with *Xmap*, not with a client application program. To interact with lines, application programs must convert them from local lines to application–owned lines via this xmap_convert_to_line ( ) command. "old_handle" and "old_client_id" are the handle and client ids of a local line. "new_client_id" is the client identification number of the application program converting the line. A new handle will be assigned to this line and returned to the client. The line is now identified by "new_client_id" and the new handle. Hence, it is no longer a local line. "conn" is the client's pkg connection structure.

Return: Handle id of line.

```
/*
~ xmap_remove_line ( )
*
* Removes a previously added line.
*/

void
xmap_remove_line (handle, client_id, conn)

int             handle;         /* Handle id of object to change */
int             client_id;      /* Client identification number. */
struct pkg_conn *conn;          /* Application program's connection to Xmap. */
```

This routine is used to remove from *Xmap* a line that was previously drawn. It does not work on local lines (see explanation in xmap_convert_to_line ( )). "handle" and "client_id" are used to uniquely identify the line being removed. "handle" was assigned to the line via xmap_convert_to_line ( ) or xmap_add_line ( ). "conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~ xmap_add_link ( )
*
* Routine used by application programs to draw links on the map.
* This routine draws NEW links, or "objects" to xmap, hence a handle id
* must be associated with the link (object).
*/

int
xmap_add_link (handle_1, client_id_1, handle_2, client_id_2, fid, client_id, conn)

int             handle_1, client_id_1;  /* Handle/client id of first (from) object) */
int             handle_2, client_id_2:  /* Handle/client id of second (to) object) */
dkb_factid_t    fid;                    /* Fact id associated with this link. */
int             client_id;              /* Client identifier number of link */
struct pkg_conn *conn;                  /* Application program's connection to Xmap. */
```

This routine is used to draw a line between two objects to show that the objects are linked together. This link is not a line in the sense that a line is an object composed of one or more line segments as created by xmap_add_line ( ) or xmap_convert_to_line ( ). Rather it is

simply intended as a means for showing that two objects are linked together in some fashion. The link follows the objects in the event that one of the object's location changes. *Xmap* removes the link if either of the objects is removed. "handle_1" and "client_id_1" uniquely define the first object being linked and "handle_2" and "client_id_2" uniquely describe the second object being linked. "fid" is the IDT factid of the fact associated with the link. "client_id" is the client identification number of the application program stating the link and "conn" is the client's pkg connection structure.

Return: Handle id of the link.

```
/*
~ xmap_remove_link ( )
*
* Routine used by application programs to remove links on the map.
*/

void
xmap_remove_link (handle, client_id, conn)

int                 handle;          / * Handle of first link to remove */
int                 client_id;       / * Client identifier number of link */
struct pkg_conn     *conn            /* Application program's connection to Xmap. */
```

This routine is used to remove a link between two objects. "handle" is the handle id of the link that was returned by xmap_add_link ( ) when the link was established. "client_id" is the client identification number of the application program that initially established the link. "conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~ xmap_add_association ( )
*
* Routine used by application programs to "bind" objects to other objects. An
* association can be formed between two objects linking them physically,
* although the link itself is invisible. The bind in effect groups the two
* objects in such a way that if one object is physically moved then the other
* object will maintain its relative position to the moved object.
*
* Objects that are associated can be associated in a MASTER_SLAVE or a GROUP
* relationship. In a MASTER_SLAVE association object 1 is slaved to object 2.
* If object 2 moves then object 1 follows it, but not vice versa. In a GROUP
* association the objects are treated as equals whereby if either object is
* moved the other object will follow it.
*/

int
xmap_add_association (handle_1, client_id_1, handle_2, client_id_2, client_id, relate, conn)

int         handle_1, client_id_1;      /* Handle/client id of first (from) object) */
int         handle_2, client_id_2;      /* Handle/client id of second (to) object) */
int               client_id;            /* Client id of program forming association */
```

```
int                 relate;         /* Relationship between binding objects. */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
```

This routine invisibly binds two objects to form an association based on the location of the objects relative to one another. "handle_1" and "client_id_1" uniquely describe the first, or 'from,' object in the association. "handle_2" and "client_id_2" uniquely describe the second, or 'to,' object in the association. "client_id" is the client identification number of the application program forming the association. "relate" describes the relationship between the two objects as described in the description above. "conn" is the client's pkg connection structure.

Return: Handle id of the association.

```
/*
~ xmap_remove_association ( )
*
* Routine used by application programs to remove associations between two
* objects.
*/

void
xmap_remove_association (handle, client_id, conn)

int                 handle;         /* Handle of first association to remove */
int                 client_id;      /* Client identifier number of association. */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
```

This routine removes a previously formed association between two objects. "handle" and "client_id" uniquely identify the association. "conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~ xmap_add_rangefan ( )
*
* Routine used by application programs to draw range fans on the map.
* This routine draws NEW range fans, or "objects" to Xmap, hence a handle id
* must be associated with the range fan (object).
*
* Return: handle id of new range fan.
*/

int
xmap_add_rangefan (unit_handle, unit_client, min_range, max_range, azimuth, trav_limits, client_id, conn)

int                 unit_handle;    /* Handle id of unit this range fan is from */
int                 unit_client;    /* Client id of unit this range fan is from */
int                 min_range;      /* Minimum range of range fan (in meters) */
int                 max_range;      /* Maximum range of range fan (in meters) */
int                 azimuth;        /* Direction of range fan (in mils) */
```

```
int                 trav_limits;    /* Traversal limits of range fan (in mils) */
int                 client_id;      /* Client identifier number of range fan */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
```

This routine instructs *Xmap* to draw a range fan based on the minimum and maximum ranges ("min_range" and "max_range," respectively), the "azimuth" (direction of centerline of range fan), and traversal limits (width of range fan in mils in either direction off of the azimuth). "min_range" and "max_range" are specified in meters. The origin of the range fan is based on the location of the object denoted by "unit_handle" and "unit_client". "client_id" is the client identification number of the application program stating the range fan. "conn" is the pkg connection structure of the client submitting the command.

Return: Handle id of the range fan.

```
/*
~ xmap_remove_rangefan ( )
*
* Routine used by application programs to remove range fans from Xmap.
*/

void
xmap_remove_rangefan (handle, client_id, conn)

int                 handle;         /* Handle of first range fan to remove */
int                 client_id;      /* Client identifier number of range fan */
struct pkg_conn     *conn;          /* Application program's connection to Xmap. */
```

This routine removes range fans from *Xmap* that were previously created using xmap_add_rangefan ( ). "handle" is the handle id assigned to the range fan when it was created. "client_id" is the client identification number of the client that created the range fan. "conn" is the pkg connection structure of the client submitting the command.

Return: Not used.

## Server Commands

Below is a list of commands available to the server program, *Xmap*, for communicating with client application programs. For each command there is a brief explanation of its intended use as well as its syntax.

```
/*
~ _xmap_connect ( )
*
* Command used by Xmap to start listening for client connections.
*/

int
_xmap_connect ( )
```

This is an initialization routine called by *Xmap* to create a network server for the indicated service. "XMAP_PORT" is a user defined number and should appear in the /etc/services file. Once the network server is initialized, the server starts listening for new connections and polls any existing connections using the 'select' system call.

Return: The file descriptor 'fd' for the network server is returned upon success, otherwise a –1 is returned.

```
/*
~ _xmap_close ( )
*
* Command used by Xmap to inform application programs of an impending
* closing of the package connection.
*/

void
_xmap_close ( conn )
struct pkg_conn      *conn;          /* Application program's connection to Xmap */
```

"Conn" is the pkg connection structure for a client that has connected to *Xmap*. *Xmap* is equipped with a 'quit' button and in the event this button is pushed xmap sends a message to any attached clients that it is terminating. This allows client applications to disconnect gracefully.

Return: Not used.

```
/*
~ _xmap_send ( )
*
* Routine for Xmap to send information to application program.
*/

void
_xmap_send (msg_type, msg, conn)
int                  msg_type;       /* Define (from libxmap.h) */
char                 *msg;           /* Contents of message */
struct pkg_conn      *conn;          /* Application program's connection to Xmap */
```

"Msg_type" is a #define that specifies the type of message that is being sent to the client application. "Msg" is the actual message. "Conn" is the client's pkg connection structure.

Return: Not used.

```
/*
~ _xmap_button_press ( )
*
* Routine for Xmap to notify application program of a button press.
*/


void
_xmap_button_press (handle, connection, button, map_x, map_y, fid, conn)

int             handle;     /* Handle id of affected object */
int             connection; /* Connection number of client */
int             button,     /* Number of button that was pressed */
                map_x,      /* X (East) map grid location of button press */
                map_y;      /* Y (North) map gird location of button press /
dkb_factid_t    fid;        /* Fact id of object pressed */
struct pkg_conn *conn;      /* Application program's connection to Xmap */
```

This routine is used to notify appropriate client applications of generic button press events. An appropriate client is one that indicated upon connecting that it wanted to be informed of any button events. A generic button press event includes a button press anywhere on the background or on a unit symbol. "Handle" is the unique identifier of the object selected by a client. "Connection" is the unique identifier of the client. These two attributes are needed for *Xmap* to distinguish one object from another. "Button" is a #define from libxmap.h that specifies which button was pressed. "Map_x" and "map_y" are the easting and northing map coordinates of the object that was selected. "Fid" is the IDT factid of the fact that is associated with the object that is selected. Sometimes this value will be NULL. "Conn" is the pkg connection of the client to notify.

Return: Not used.

```
/*
~ _xmap_line_click ( )
*
* Routine for Xmap to notify application program of a line click.
*/

void
_xmap_line_click (handle, connection, button, fid, coords, conn)

int             handle;     /* Handle id of affected object */
int             connection; /* Connection number of client */
int             button;     /* Button that was pressed to generate this even
dkb_factid_t    fid;        /* Fact id of object pressed */
char            *coords;    /* A string containing all the grid coordinates */
```

```
struct pkg_conn     *conn;          /* Application program's connection to Xmap */
```

This routine is used to inform an appropriate client of a line selection. An appropriate client is the same as defined in _xmap_button_ press ( ). "Handle," "connection," "button," "fid," and "conn" are the same as described in _xmap_button_press ( ). "Coords" is a string consisting of all the UTM coordinates of the line segments that make up the line.

Return: Not used.

```
/*
~ _xmap_line_change ( )
*
* Routine used by Xmap to notify application programs of changes to already
* drawn lines. The complete list of new coordinates is specified.
*/

void
_xmap_line_change (client_id, handle, fid, coords, conn)

int             client_id;      /* Client identifier number. */
int             handle;         /* Handle id of line */
dkb_factid_t    fid;            /* Fact id associated with this line. */
char            *coords;        /* List of coords defining line segments. */
struct pkg_conn *conn;          /* Application program's connection to Xmap. */
```

This routine is used to notify an appropriate client of a change to a line. An appropriate client is the same as described in _xmap_send(). *Xmap* gives the user the ability to edit an existing line. When this is done, the appropriate clients must be informed of the changes so they can update their database if necessary. Note that it is *Xmap* which provides the capability to edit lines, not client application programs. "Handle," "connection," "button," "fid," and "conn" are the same as described in _xmap_butt on_ press ( ). "Coords" is the same as described in _xmap_line_click (). The coords string setup looks like: "x y; x y; ....". This setup allows for ease of parsing.

Return: Not used.

```
/*
~ _xmap_symbol_change ( )
*
* Routine for Xmap to notify application program of a change in location
* of a symbol that is the SLAVE in an association.
*/

void
_xmap_symbol_change (handle, connection, map_x, map_y, fid, conn)

int             handle;         /* Handle id of affected object */
int             connection;     /* Connection number of client */
int             map_x,          /* X (East) map grid location of button press */
                map_y;          /* Y (North) map grid location of button press */
dkb_factid_t    fid:            /* Fact id of object pressed */
struct pkg_conn *conn;          /* Application program's connection to Xmap */
```

This routine is used to inform a client application program of a change in location of the SLAVE in an association (relationship: MASTER–SLAVE). For a more detailed description of associations see the description for xmap_add_association ( ). "Handle," "connection," "map_x," "map_y," "fid," and "conn" are the same as described in _xmap_button_press().

Return: Not used.

```
/*
~ _xmap_error ( )
*
* Routine for Xmap to notify application program of an error in an action
* that the application program sent Xmap.
*/

void
_xmap_error (handle, msg_type, conn)

int             handle;     /* Handle id of affected object */
int             msg_type;   /* Message type from application program */
struct pkg_conn *conn;      /* Application program's connection to Xmap */
```

This routine is used to inform the clients of errors made in an action that the client sent to *Xmap*. This could include mixing up the order of attributes, sending inappropriate data types, specifying unknown objects, etc. It is the client's responsibility to correct the error condition. "Msg_type" and "conn" are the same as described in _xmap_send ( ). "Handle" is the same as described in _xmap_button_press ( ).

Return: Not used.

INTENTIONALLY LEFT BLANK.

# ACRONYMS

| | |
|---|---|
| ACISD | Advanced Computational and Informational Sciences Directorate |
| ARL | Army Research Laboratory |
| CNR | Combat Net Radios |
| HELCAP | Human Engineering Laboratory Counter–Air Program |
| IDT | Information Distribution Technology |
| MCSB | Military Computer Science Branch |
| SWS | Smart Weapons Systems LABCOM Cooperative Program |

INTENTIONALLY LEFT BLANK.

| No. of Copies | Organization |
|---|---|
| 2 | Administrator<br>Defense Technical Info Center<br>ATTN: DTIC-DDA<br>Cameron Station<br>Alexandria, VA 22304-6145 |
| 1 | Commander<br>U.S. Army Materiel Command<br>ATTN: AMCAM<br>5001 Eisenhower Ave.<br>Alexandria, VA 22333-0001 |
| 1 | Director<br>U.S. Army Research Laboratory<br>ATTN: AMSRL-OP-CI-AD,<br>Tech Publishing<br>2800 Powder Mill Rd.<br>Adelphi, MD 20783-1145 |
| 1 | Director<br>U.S. Army Research Laboratory<br>ATTN: AMSRL-OP-CI-AD,<br>Records Management<br>2800 Powder Mill Rd.<br>Adelphi, MD 20783-1145 |
| 2 | Commander<br>U.S. Army Armament Research,<br>Development, and Engineering Center<br>ATTN: SMCAR-TDC<br>Picatinny Arsenal, NJ 07806-5000 |
| 1 | Director<br>Benet Weapons Laboratory<br>U.S. Army Armament Research,<br>Development, and Engineering Center<br>ATTN: SMCAR-CCB-TL<br>Watervliet, NY 12189-4050 |
| 1 | Director<br>U.S. Army Advanced Systems Research<br>and Analysis Office (ATCOM)<br>ATTN: AMSAT-R-NR, M/S 219-1<br>Ames Research Center<br>Moffett Field, CA 94035-1000 |

| No. of Copies | Organization |
|---|---|
| 1 | Commander<br>U.S. Army Missile Command<br>ATTN: AMSMI-RD-CS-R (DOC)<br>Redstone Arsenal, AL 35898-5010 |
| 1 | Commander<br>U.S. Army Tank-Automotive Command<br>ATTN: AMSTA-JSK (Armor Eng. Br.)<br>Warren, MI 48397-5000 |
| 1 | Director<br>U.S. Army TRADOC Analysis Command<br>ATTN: ATRC-WSR<br>White Sands Missile Range, NM 88002-5502 |
| (Class. only) 1 | Commandant<br>U.S. Army Infantry School<br>ATTN: ATSH-CD (Security Mgr.)<br>Fort Benning, GA 31905-5660 |
| (Unclass. only) 1 | Commandant<br>U.S. Army Infantry School<br>ATTN: ATSH-WCB-O<br>Fort Benning, GA 31905-5000 |
| | Aberdeen Proving Ground |
| 2 | Dir, USAMSAA<br>ATTN: AMXSY-D<br>AMXSY-MP, H. Cohen |
| 1 | Cdr, USATECOM<br>ATTN: AMSTE-TC |
| 1 | Dir, USAERDEC<br>ATTN: SCBRD-RT |
| 1 | Cdr, USACBDCOM<br>ATTN: AMSCB-CII |
| 1 | Dir, USARL<br>ATTN: AMSRL-SL-I |
| 5 | Dir, USARL<br>ATTN: AMSRL-OP-AP-L |

| No. of Copies | Organization |
|---|---|
| | Aberdeen Proving Ground |
| 12 | Dir, USARL<br>ATTN: AMSRL-CI-C, Walter B. Sturek<br>AMSRL-CI-CC,<br>Samuel C. Chamberlain<br>Douglas A. Gwyn<br>George W. Hartwig, Jr.<br>Maria C. Lopez<br>Barry R. Reichard<br>AMSRL-CI-S, Andrew Mark<br>AMSRL-CI-SA, Eric G. Heilman<br>AMSRL-CI-SB,<br>Virginia A. Kaste<br>Janet F. O'May<br>AMSRL-SL-BG, Frederick S. Brundick<br>AMSRL-SL-BS, Howell Caton |

## USER EVALUATION SHEET/CHANGE OF ADDRESS

This Laboratory undertakes a continuing effort to improve the quality of the reports it publishes. Your comments/answers to the items/questions below will aid us in our efforts.

1. ARL Report Number ARL-TR-498 Date of Report August 1994

2. Date Report Received _____

3. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which the report will be used.) _____

4. Specifically, how is the report being used? (Information source, design data, procedure, source of ideas, etc.) _____

5. Has the information in this report led to any quantitative savings as far as man-hours or dollars saved, operating costs avoided, or efficiencies achieved, etc? If so, please elaborate. _____

6. General Comments. What do you think should be changed to improve future reports? (Indicate changes to organization, technical content, format, etc.) _____

CURRENT ADDRESS

_____
Organization

_____
Name

_____
Street or P.O. Box No.

_____
City, State, Zip Code

7. If indicating a Change of Address or Address Correction, please provide the Current or Correct address above and the Old or Incorrect address below.

OLD ADDRESS

_____
Organization

_____
Name

_____
Street or P.O. Box No.

_____
City, State, Zip Code

(Remove this sheet, fold as indicated, tape closed, and mail.)
(DO NOT STAPLE)

DEPARTMENT OF THE ARMY

OFFICIAL BUSINESS

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

**BUSINESS REPLY MAIL**
FIRST CLASS PERMIT NO 0001, APG, MD

Postage will be paid by addressee

Director
U.S. Army Research Laboratory
ATTN: AMSRL-OP-AP-L
Aberdeen Proving Ground, MD 21005-5066